CLAIMS

We claim:

1. A moving coil motor, comprising:

a fixed frame;

a movable member supported by the fixed frame for movement in at least one degree of freedom with respect to a nominal plane;

a magnet means for creating a generally axisymmetrical magnetic field having a magnetic axis substantially orthogonal to the nominal plane of the movable member;

at least one electrically conductive element on the movable member, positioned about the magnetic axis and configured such that current flow through the electrically conductive element interacts with the magnetic field of the magnet means to create Lorentz forces to move the movable member in one or more degrees of freedom.

2. A moving coil motor as in claim 1, wherein the magnetic field of the magnet means includes a generally radial component with respect to the magnetic axis, which acts on the electrical conductive elements.

3. A moving coil motor as in claim 1, wherein the electrical conductive elements are disposed in a generally circumferential symmetry with respect to the magnetic axis of the magnet means.

4. A moving coil motor as in claim 3, wherein the electrically conductive elements include at least one coil configured to interact with the magnetic field to effect tilting movement of the movable member.

5. A moving coil motor as in claim 4, wherein the electrical conductive elements include at least two coils configured to interact with the magnetic field to effect tilting movement of the movable member about at least two axes with respect to the nominal plane of the movable member.

6. A moving coil motor as in claim 5, wherein the electrical conductive elements include first and second pairs of coils, wherein the first pair effects tilting movement of the movable member about a first axis with respect to the nominal plane of the movable member, and the second pair effects tilting movement of the movable member about a second axis with respect to the nominal plane of the movable member.

7. A moving coil motor as in claim 6, wherein the first and second axes are substantially orthogonal to the magnetic axis of the magnetic means.

8. A moving coil motor as in claim 1, wherein the magnet means comprises a ferromagnetic material having a remnant magnetic field, and having a magnetic axis aligned with an axis substantially orthogonal to the nominal plane of the movable member.

9. A moving coil motor as in claim 1, wherein the magnet means comprises a generally cylindrical ferromagnetic assembly having at least one ferromagnetic material with a remnant magnetic field, and having a magnetic axis aligned with an axis substantially orthogonal to the nominal plane of the movable member, the ferromagnetic assembly comprising a first ferromagnetic material along the axis, and a second ferromagnetic material coaxially positioned about the first ferromagnetic material.

10. A moving coil motor as in claim 1, wherein the nominal plane of the movable member is a position in which all the electrical conductive elements are not carrying current.

11. A moving coil motor as in claim 1, wherein the movable member contains a reflective surface.

12. A moving coil motor as in claim 1, wherein the fixed frame comprises one or more parallel oriented support structures for holding the movable member.

13. A moving coil motor as in claim 12, wherein the fixed frame includes parallel oriented top and base support structures.

14. A moving coil motor as in claim 13, wherein the top and base support structures are coupled by a middle spacing member.

15. A moving coil motor as in claim 14, wherein the middle spacing member is a ball grid array.

16. A moving coil motor as in claim 1, wherein the movable member and the fixed frame are fabricated from a monocrystalline substrate.

17. A moving coil motor as in claim 1, wherein the movable member is suspended from the fixed frame by at least one spring coupled to the periphery of the movable member.

18. A moving coil motor as in claim 17, wherein said at least one spring is cantilevered from the fixed frame and supports the movable member.

19. A moving coil motor as in claim 18, wherein said at least one spring is unitary to the fixed frame and movable member.

20. A moving coil motor as in claim 17, wherein there a plurality of springs, and said springs are positioned axisymmetrically about the movable member.

21. A moving coil motor as in claim 20, wherein the fixed frame defines a space in which the movable member is supported by the springs, and each spring is cantilevered from the frame, extending in a slender, generally arcuate fashion.

22. A moving coil motor as in claim 21, wherein the fixed frame defines a generally square space in which the movable member is supported, wherein each spring is cantilevered from substantially a corner of the fixed frame, and wherein each spring extends to support the movable member at a position near an adjacent corner of the fixed frame.

23. A moving coil motor as in claim 1, further comprising position sensing means for sensing spatial position of the movable member.

24. A moving coil motor as in claim 23, wherein the position sensing means comprises means for sensing tip and tilt position based on inductive coupling principles.

25. A moving coil motor as in claim 23, wherein the position sensing means comprises a transmitter coil and a receiver coil, and wherein the transmitter coil is supported on the movable member, and the receiver coil is supported on either the top or base support structure of the fixed frame in an inductively coupled manner.

26. A moving coil motor as in claim 23, wherein the position sensing means comprises a transmitter coil and a receiver coil, and wherein the transmitter coil is supported on either the top or base support structure of the fixed frame in an inductively coupled manner, and the receiver coil is supported on the movable member in an inductively coupled manner.

27. A moving coil motor as in claims 25 or 26, wherein the position sensing means includes means for sending a high frequency AC signal to the transmitter coil and sensing a voltage drop in the receiver coil to determine the position of the movable member.

28. A moving coil motor as in claims 25 or 26, wherein the electrically conductive elements are also configured to function as the transmitter or receiver coil.

29. A moving coil motor as in claim 28, wherein the electrically conductive elements are supported on a side of the movable member that opposes the transmitter or receiver coil on the fixed frame.

30. A moving coil motor as in claim 29, wherein the transmitter or receiver coil supported by the fixed frame is supported on top of the base support structure coupled to the fixed frame, and the electrically conductive elements are supported on the underside of the movable member facing the coil on the base support structure.

31. A moving coil motor as in claim 28, wherein the electrically conductive elements are supported on a top side of the movable member, and the transmitter or receiver coil supported by the fixed frame is supported on the top of the base support structure coupled to the fixed frame, facing an underside of the movable member.

32. A moving coil motor as in claim 31, wherein the receiver or transmitter coil on the base support structure comprises a circumferential coil of electrically conducting elements having a span in operative relationship with the transmitter or receiver coil, respectively, on the movable member.

33. A moving coil motor as in claim 1, further comprising a tier member supported on the movable member, wherein the tier member defines a working surface.

34. A moving coil motor as in claim 33, wherein the working surface is a reflective surface.

35. A moving coil motor as in claim 1, wherein the electrically conductive elements are supported on an underside of the movable member towards the magnetic means, and the movable member comprises a top side defining a working surface.

36. An optical switch for use in an optical network, comprising:

a moving coil motor as defined in claim 1; and

a reflective surface defined on the movable member for receiving an incident light.

37. An optical switch as in claim 36, further comprising control means for controlling movement of the movable member to reflect light at a desired target.

38. An array of moving coil motors, comprising:

a fixed frame;

a plurality of moving coil motors, each comprising:

(a) a movable member supported by the fixed frame for movement in at least one degree of freedom with respect to a nominal plane;

(b) a magnet means for creating a generally axisymmetrical magnetic field having a magnetic axis substantially orthogonal to the nominal plane of the movable member;

(c) a plurality of electrical conductive elements on the movable member, positioned about the magnetic axis and configured such that current flow through the electrical conductive elements interacts with the magnetic field of the magnet means to create Lorentz forces to move the movable member in one or more degrees of freedom.

39. An array of moving coil motors as in claim 38, wherein the magnet means for the moving coil motors comprises a first array of ferromagnetic elements each having a remnant magnetic field, and each having a magnetic axis aligned with an axis substantially orthogonal to the nominal plane of the corresponding movable member.

40. An array of moving coil motors as in claim 39, wherein the array of ferromagnetic elements may be configured using discrete assemblies, or may be interspersed in a solid ferromagnetic substrate in a manner to create a generally radial magnetic field with respect to each of the movable members.

41. An array of moving coil motors as in claim 39, wherein the first array of ferromagnetic elements defines alternating polarity between adjacent elements, in a manner defining a generally radial magnetic field with respect to each of the movable members.

42. An array of moving coil motors as in claim 39, wherein the first array of ferromagnetic elements defines a first polarity for each adjacent element, and the magnet means further comprises a second array of ferromagnetic elements defining a second polarity, each positioned between adjacent elements of the first array in a manner to create a generally radial magnetic field with respect to each of the movable members.

43. An array of moving coil motors as in claim 41, wherein the magnet means further comprises additional ferromagnetic elements positioned beyond the array of moving coil motors so as to maintain axisymmetry of the magnet fields at the moving coil motors near the boundary of the array of the moving coil motors.